

强震作用下穿越断层隧道围岩力学响应研究

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ROCK DYNAMIC RESPONSE OF RAILWAY TUNNEL TRAVERSING THROUGH FAULT UNDER STRONG EARTHQUAKE

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摘要 通常情况下,地下工程震害比地面建筑物震害较轻,但是在强震条件下,地下工程震害依然突出。2008年 5·12 汶川大地震 ($M_S 8.0$)对地下工程造成了巨大破坏,尤其是穿越构造断裂带的铁路、公路隧道。本文采用三维离散元(3DEC)动力分析方法和实测汶川地震记录,模拟研究了穿越断层的成兰铁路邓家坪隧道围岩在强震和断层共同作用下的动力响应过程。经过与实地调查的北川—映秀断裂带地表破裂情况对比验证,模拟结果具有较高的可信度。结果表明:地震动荷载、断层等因素的共同作用改变了隧道围岩中的初始应力分布,进而引起断层附近隧道围岩应力累积、应力集中,最终导致了具有高度复杂性的渐进性断层破裂过程和隧道围岩破坏过程,这个过程可以定性地划分为5个主要阶段:弹性应力集中阶段、破裂起始阶段、破裂加速阶段、稳定破裂阶段和破裂逐渐停止阶段。本研究将有助于深刻认识在强震和断层共同作用下的隧道围岩动力响应过程,并对隧道安全性评价具有重大意义。

关键词: 隧道 强震 断层 渐进破坏过程 三维离散元

Abstract: Usually, the earthquake-induced damage to underground structures is lighter than that to above-ground structures. But, under the condition of strong earthquakes and faults, the earthquake-induced damage to underground structures is still considerably serious. On May 12, 2008, Wenchuan earthquake with a magnitude of $M_s 8.0$ in Sichuan province, China caused tremendous damage to underground structures, especially the tunnels of railways and roads that traverse active faults. Dengjiaping tunnel of Cheng-Lan Railway (Chengdu to Lanzhou, in China) traverses the central fault belt in Longmenshan zone with complex geological conditions and developed active faults. This study uses dynamic module of 3 Dimensional Discrete Element Code (3DEC) and acceleration histories of Wenchuan earthquake in Qingping station to investigate the dynamic response process of Dengjiaping tunnel under the combined effects of strong earthquake and fault. Verified by comparing the ground motion of field survey and modeling results, the modeling results have high reliability. The modeling results show that the combined effects of strong earthquake and fault disturb the initial field stress distribution and cause the stress accumulation and stress concentration of tunnel surrounding rock near faulting zone. The high stress concentration results in fault gradual rupture and tunnel gradual failure, which can be qualitatively divided into 5 stages: 1) elastic stress accumulation, 2) local rupture beginning, 3) rupture growth at high speed, 4) spontaneous rupture growth, 5) gradual stability state. This study is helpful to understand the dynamic response process of tunnel surrounding rock under the combined effect of strong earthquakes and faults, and has considerable significance for tunnel safety estimation.

Key words: Tunnel Earthquake Fault Gradual failure process 3DEC

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